DOCUMENT RESUME

ED 397 808 IR 017 996

AUTHOR Lambdin, Diana V.; And Others
TITLE A Hypermedia System To Aid in Preservice Teacher Education: Instructional Design and Evaluation.
PUB DATE 96
NOTE 17p.; In: Proceedings of Selected Research and Development Presentations at the 1996 National Convention of the Association for Educational Communications and Technology (18th, Indianapolis, IN, 1996); see IR 017 960.
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Courseware; Curriculum Development; Educational Philosophy; Elementary Education; Field Experience Programs; Graduate Students; Information Systems; *Instructional Effectiveness; *Interactive Video; Mathematics Instruction; *Preservice Teacher Education; Self Evaluation (Individuals); *Student Attitudes; Teaching Methods; Teaching Styles; *Videodisks
IDENTIFIERS Reflecting (Communication)

ABSTRACT

This research investigated how use of an interactive videodisk information system, the Strategic Teaching Framework (STF), helped preservice teachers expand their visions of teaching, learning, and assessment in mathematics, and helped develop their skills in translating that vision into action in the classroom. STF consisted of videos of classroom situations, with various behaviors and techniques on display. The technology was used as one element in the field experience component of a Master's certification program for prospective elementary teachers, and provided them with models of effective teaching around which class discussions and individual journal reflections were based. The data that was collected documents how students felt about the value of specific STF features, STF's "fit" as a curriculum component, and STF's impact on understanding. Reactions indicated that STF aided students in class arrangement, self-criticism, and feedback to fellow learners. It also stimulated reflection about teaching philosophies that continued to develop throughout the course. (Contains 24 references.) (Author/BEW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED 397 808

Title:

A Hypermedia System to Aid in Preservice Teacher Education: Instructional Design and Evaluation

Authors:

Diana V. Lambdin, Thomas M. Duffy, and Julie A. Moore
Indiana University, Bloomington, IN

IR017996

BEST COPY AVAILABLE

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

M. Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC).

This research investigated how use of an interactive videodisk information system helped preservice teachers (PSTs) expand their visions of teaching, learning, and assessment in mathematics and their skills in translating that vision into action in the classroom. The technology was used as one element in the field experience component of a masters certification program for prospective elementary teachers and provided them with models of effective teaching around which class discussions and individual journal reflections were based. The data we collected document how students used the technology in formulating personal visions of effective teaching, how they planned and taught lessons to actual classes of children, how they critiqued their own teaching and the teaching of others, and how their philosophies and beliefs about teaching and learning developed throughout the course.

Rationale

Changes are in the air in schools in the United States: changes in curricula, changes in teaching methods, and changes in assessment. As a result, teacher education must change as well. In March 1989, the National Council of Teachers of Mathematics (NCTM) released its Curriculum and Evaluation Standards for School Mathematics. Central to the message of the Curriculum and Evaluation Standards is the development of mathematical power for all students, described as the ability "to explore, conjecture, and reason logically as well as the ability to use a variety of mathematical methods effectively to solve nonroutine problems. This notion is based on the recognition of mathematics as more than a collection of concepts and skills to be mastered; it includes methods of investigating and reasoning, means of communication, and notions of context" (NCTM, 1989, p. 5).

Research findings from cognitive psychology and mathematics education indicate that students learn as they actively assimilate new information and experiences to construct their own meanings (Case & Bereiter, 1984; Cobb & Steffe 1983; David, 1984; Hiebert, 1986; Lampert, 1986, 1990; Schoenfeld, 1987). Since this is—of course—just as true of the learning of prospective teachers as of any students, we as teacher educators must practice what we teach. That is, we cannot hope to produce teachers who can adapt to new notions of what it means to teach mathematics unless we change our own teaching practices as well.

Recognizing that reaching the goal of developing mathematical power for all students requires teachers with new and different philosophies and competencies, the NCTM published—in 1991—a companion set of standards: the Professional Teaching Standards for School Mathematics. This document identifies the need for mathematics teachers who are proficient—among other things— in "selecting mathematical tasks to engage students' interests and intellect; providing opportunities to deepen students' understanding of the mathematics being studied and its applications; orchestrating classroom discourse in ways that promote the investigation and growth of mathematical ideas; using, and helping students use, technology and other tools to pursue mathematical investigations; seeking, and helping students seek, connections to previous and developing knowledge; [and] guiding individual, small-group, and whole-class work" (NCTM, 1991, p. 1).

The goal of this research study was to investigate how use of an interactive videodisk information system (the Strategic Teaching Framework) in a field experience course for preservice teachers (PSTs) might help them expand their visions of teaching, learning, and assessment in mathematics and their skills in translating that vision into action in the classroom.

The Strategic Teaching Framework

Strategic Teaching Framework[9] (STF) is an interactive videodisk information system designed to help individuals develop teaching strategies that are problem-solving oriented, that focus on both students and processes, and that utilize collaborative work as a means for testing ideas. The system is written in Hypercard and runs on a Macintosh computer. Videos of classrooms are stored on videodisk with presentation of the video and supporting materials controlled through the STF interface.

STF was designed to support teachers through a constructivist or process-oriented learning environment (Duffy, in press)—in particular, the sort of environment reflected in models of cognitive apprenticeship (Brown, Collins, & Duguid, 1989) and of the reflective practitioner (Schon, 1989). The STF module consists of video of a full class period

---

[9] Strategic Teaching Framework was a joint project of Indiana University and the North Central Regional Education Laboratory. Lead designers for the program were Thomas Duffy, Beau Jones, and Randy Knuth.

of teaching by three elementary school teachers[10], each of whom exhibits characteristics consistent with the recommendations of the Professional Teaching Standards (NCTM, 1991). One of the STF design strategies was to provide access to multiple, sometimes very different, representations of exemplary (learner-centered, collaborative, problem driven) practice to aid prospective teachers in understanding that the teaching strategies illustrated should not be seen as practices to be slavishly imitated but, rather, as providing the underpinnings for a conceptual framework to guide practice.

The videos of the three teachers each teaching a full class period of instruction is the heart of the STF system. STF very consciously does not focus on isolated skills or on idealized demonstrations, but instead emphasizes the interrelatedness of teaching practices by presenting them in context. The design strategy was to avoid teaching the critical attributes in the video for two reasons. First, the critical points or attributes in an actual teaching experience are really a matter of one's perspective rather than a reality. Second, within the constructivist and apprenticeship mode, the goal was to aid the learner in developing and evaluating his or her own perspective on critical issues. It was believed that learning would be more effective if it was learner (teacher) centered rather than system specified. The perspectives provided on the teaching in the videos further reflected this design strategy of supporting the teacher-learner's constructive activity and providing a basis for testing those constructions. Rather than a single perspective on the important aspects of the teaching, STF provides commentary from three different perspectives: the featured teacher, a mathematics educator, and the STF developers. The perspectives are "attached" to the video, so that the learner can obtain the three perspectives on the particular teaching activity currently being viewed.

A second part of the STF information system is a conceptually organized information base. Topics include assessment, management, teaching strategies, problem solving, and planning. For each of these topics there are 4 to 12 subtopics, and for each subtopic the learner can get several types of information: perspectives on the video and the videoclip that are directly related to that subtopic; references to a specific reference article in a hardcopy library that is part of STF; or an interview with the teacher or with one of three education experts. Thus, after studying the classroom as a whole, the learner can move to the information base to develop a richer understanding of various aspects of the teaching. Additionally, a notetaking feature is built in to the system to allow users to attach their own comments to or establish a dialogue around a video segment.

The Research Agenda

The focus of this research project was the design and formative evaluation of an instructional model to support the use of STF in mathematics teacher education. Because this was a first evaluation of the STF system in a teaching context, it was important to document in considerable detail how the students worked with the STF system and how they implemented—in their field experience classrooms—the strategies illustrated by STF. We also were interested in describing the extent to which the PSTs exhibited reflective, situated decision making during teaching. Data on use of STF came from observations, student journals, and computer logs of the frequency and types of use. (These data will also serve later to guide revision of the system.)

Our instructional model emphasized PSTs' construction and testing (through collaboration, observation, and practice) of their own conceptual frameworks for what it means to teach mathematics according to the recommendations of the NCTM standards documents. It also encouraged the prospective teachers to reflect both on teaching practices and on students' learning—a promising strategy for changing the way mathematics is taught, learned, and assessed (Tobin, 1989). When PSTs actively participate in evaluating classroom lessons, they can begin to create new, more effective frameworks for helping the students they teach make mathematical connections.

Our instructional model contained elements of both the cognitive apprentice and the reflective practitioner models of teacher education (Duffy, in press). Central to both of these models is the notion that learning must be purposeful—that there should be a realistic task or goal for which the learning will be used. This notion provides learners with a framework for developing self regulation in identifying learning goals, carrying out designated tasks, and self-assessing progress in learning through accomplishing the task. In our model, the task was for each PST to develop and deliver mathematics instruction to the class of elementary students to which he or she had been assigned for a semester-long early field experience in mathematics and science teaching.

Consistent with the cognitive apprenticeship model, STF provides—through its video exemplars, its clips of expert commentary, and its library of resources—expert models and multiple perspectives on their performance. Further,

---

[10] These exemplary teachers are Vickie Bill, St. Agnes Elementary School, Pittsburgh; David Birchfield, Brownsville Elementary School, Charlottesville VA; and Dwight Cooley, Alice Carlson Applied Learning Center, Ft. Worth TX. At the time of this study, Dwight Cooley had not yet been added to the STF system. His class was only available on videotape.

collaboration among peers, as well as interactions with the university supervisor, the cooperating teachers, and the elementary students in the classrooms provided a vehicle for the PSTs to develop and test their own conceptual frameworks for instruction. Consistent with the reflective practitioner model, our use of STF emphasized a cycle of reflection-in-action. This reflection-in-action began with the PSTs reflecting on the action of two teachers in the STF video, moved next to reflections on the teaching of the cooperating teacher in the field experience classroom, and progressed to reflection on the PST's own performance in the classroom.

This paper focuses specifically on the use and impact of STF in a course for PSTs, though the work reported here represents just a portion of a larger study designed to examine the PST's growth in thought and action and development as reflective practioners.

Method

Subjects

The subjects in the study were 16 preservice teachers enrolled in Indiana University's Elementary Certification Graduate Program (ECGP). Students in the class of sixteen ranged from 23 - 45 years of age,. Only one student (Pete[11]) was already a certified teacher (of secondary social studies), but several students had experience as substitute teachers, tutors, or classroom volunteers. Roughly half the class was married, and many had children at home. All students were changing current careers to become elementary teachers. The class was composed of ten women and six men.

All of these students contributed to the data on the use of STF. Eight of them, four men and four women, were selected for a more intensive analysis of their journals and other reflective contributions regarding their beliefs, attitudes and strategies for using STF and its contribution to their growth as a perspective teacher. These students were selected at the end of data collection, but prior to any analysis, based on two criteria. First, they had written extensive journals. Second, in the teacher's estimation and based on class assessment instruments, these eight students seemed to represent a cross section of the class in terms of range of their understanding of learner centered instruction, their classroom experiences, and their growth over the course of the semester.

The Teacher Education Program

The ECGP program is designed for students who already have liberal arts, humanities, or social or natural science baccalaureate degrees, but have returned to the university to work concurrently on certification as elementary teachers and a masters degree. The program seemed a particularly appropriate site for experimenting with use of STF in a teacher education setting because the ECGP program was explicitly founded upon the following principle: "Teacher education is viewed primarily as a process of praxis. Students are assisted to construct their own personal theories of education (based upon personal experiences and course experiences), are given opportunities to test these theories in a variety of field experiences, and are continually encouraged to reflect upon all three types of experiences (personal, course, and field) in revising and reconceptualizing their theories" (ECGP Program Description, 1993, p. 3).

The Curriculum and Course

The students were concurrently enrolled in E543 (Advanced Study in the Teaching of Mathematics in the Elementary School) and M501 (Laboratory/Field Experience,), both taught by the first author. Use of STF was a new, but integral, part of the ECGP M501 field experience.

M501 is an early field experience course scheduled to meet one full day per week for a semester. As part of the, course, each prospective teacher is assigned to an elementary school classroom and spends one day per week for about 12 weeks at the school with that teacher and his or her class. The PSTs enrolled in M501 are given four mathematics assignments to be carried out in the school: (1) to conduct a series of interviews with three children— at diverse levels of ability — in an elementary school classroom, and (2) - (4) to design and present three mathematics lessons to the class as a whole.

Before developing their interview questions, the PSTs view a videotape on effective, interviewing techniques for mathematics assessment (Burns, 1993). They then conduct their interviews with children, audio-recording one of them for later review, transcription, and analysis in a paper written for the course. The interview assignment serves two purposes: to provide the PSTs with a detailed look at how children of a particular age think about mathematical concepts and solve problems, and to encourage them to reflect on their own ideas about children's understandings and their own questioning techniques.

---

[11] Names used are psueudonyms for students in the study.

In each of the three lessons that the PSTs design and teach (two of which are eventually self-critiqued in course papers), they are instructed to incorporate at least one of the following: collaborative learning, the use of manipulatives, teaching a mathematical concept via problem solving, and deriving mathematical problems from narratives (i.e., literature-based mathematics teaching). These aspects of mathematics instruction are supported by recommendations of the NCTM Standards and are also illustrated in the STF module.

Incorporating the use of STF into the M501 curriculum required a reallocation of time during the course. For weeks two to five of the term, students spent half of their M501 course time (that is, one afternoon per week) at the university working with STF and on the design of lesson plans. During these same weeks, the other half of their M501 course time, (that is, one morning per week) was spent either in teaching workshops (during weeks two and three) or in work in their field experience classroom at the school (during weeks four and five). From the 6th to the 13th week of the term, the PSTs spent an entire day each week in their field experience classrooms, but had a one-hour meeting per week at the university for discussion and debriefing (as well as three hours per week in Mathematics Methods class — where considerable discussion about teaching took place as well). The PSTs' teaching of mathematics lessons in the schools was done during weeks 6-9 of the semester.

The resources available to the prospective teachers as they planned their lessons included:

- The classroom to which they were assigned (as a source of information on the culture of the classroom and the skills/knowledge/problem solving strategies of the children).
- The mathematics methods class (as a source of information on appropriate content and sequencing for math instruction).
- STF (as a source of information on mathematics teaching strategies and goals).

STF Facilities

Four Apple IIci workstations were available for the class. The peripherals associated with each computer included a CD-ROM player, video disk player, and monitor. Copies of the STF software and videodisks were kept with each workstation. Students were also able to check out videotapes and hardcopies of the CD-ROM information for home use.

The computers were in laboratory settings which included a large table and space for the team to gather and work. Other students in one of the School's programs had access to these computers for their work, but the PSTs had priority and were able, to access the machines any time they desired. The shared access, however, did mean that some reconfiguring was often necessary before the students could work. The two most frequent issues were disconnecting the machines from the network and reattaching the CD ROM player as a peripheral.

Strategy for Using STF

There were STF based classroom assignments each Monday afternoon for weeks 2-5 of the class (the first week was spent orienting students to the course). For this paper, these weeks will be referred to as STF week 1 (or session 1), STF week 2 (session 2), etc.. Additionally the students had access to STF at any time throughout the semester. The students worked with STF in teams of four to five, with each team assigned to one of the four computers.

In the first STF session, the M501 class examined the teaching of one of the three teachers in the STF system (Vickie Bill). Each group viewed the video of Vickie Bill's lesson with the goal of identifying the key features of her approach to teaching and analyzing how and why these components of the teaching are important. These analyses were then shared in the final hour of the class, in whole-class discussions and further elaborated upon in individual journal assignments. As part of their reflective journals (which were turned in weekly for commentary by the first and third authors), PSTs recorded their thoughts on the implications of their analysis of the STF teachers for their own images of effective mathematics teaching and for their own soon-to-be written mathematics lesson plans.

In STF week 2, the students discussed further their reaction to Vickie Bill, then were sent in their groups to watch and analyze second teacher in the STF system, David Birchfield. As with Vicki, they were asked to identify the key features of David's teaching and analyze how and why these components were important. During the week, students were asked to continue to analyze the teaching of David Birchfield, focusing on questioning strategies. Discussion, analysis, and reflection via journal ensued similar to that of week 1, with additional emphasis on analyzing both David and Vickie's questioning strategies.

In STF week 3, students were sent in their groups to the STF stations immediately, to identify and prepare to bring back to the class examples of Vickie and David which exemplified what they believed to be key elements to teaching (which required the group to come to consensus on those elements first). Students spent the last half of the

BEST COPY AVAILABLE

class presenting their STF examples and engaging in discussion about them. Journal entries for this week focused on their questions, concerns, and insecurities about their field experience (they had visited their classrooms for the first time that morning). They were asked to use STF to explore and comment on these issues.

The fourth week of STF work involved students in actually conceptualizing and writing a plan for a mathematics lesson. This planning was done in small groups, shared and critiqued in whole class discussion, and then became the topic of a reflective writing assignment for individuals' journals.

Field Experience

The PSTs were each assigned to an elementary (grades 1 to 6) classroom and teacher in one of two schools within a twenty minute drive of the University. Once the students were working full-time in the elementary school (beginning in week 5), they proceeded to the tasks of conducting their diagnostic interviews and planning and teaching their three lessons. Each week they wrote extensive commentary in their field experience journals about observations they were making in the classroom, issues that were arising, beliefs that were being challenged, and successes and failures that they were experiencing. The students were encouraged to return, whenever it seemed useful, to STF as a resource.

Between weeks six and nine the students were required to teach three mathematics lessons in the elementary classroom. The first and third authors attended at least one of the teaching sessions of each PST and provided written feedback to the students afterward. They were also videotaped during at least one of the three lessons. Videotaping was done by students in another program in the school. The tape was given to the PST after class with instructions to watch the video, analyze the teaching, reflect on their own performance, and write a thoughtful critique.

Data Sources and Analysis

Data about students' use of and attitudes about the STF system were collected in a number of ways. Keystroke data, student journals, and reflections on videotapes of their own teaching provided the researchers with information about the use and impact of STF throughout the entire semester. Additionally, the teacher of the class (the first author) provided reflections of the use and impact of STF from the instructor's perspective.

Keystroke data. STF software included a program to record login information and the time of all keystrokes while using the program. This data provided us with a record of what STF features were used by whom, when, and for how long.

Student reflective journals The students kept weekly journals in which they reflected on their use of the STF system, their growing understanding of effective teaching, and their reactions to their field experiences and class activities. The first and third authors responded in writing to these journal entries weekly, creating a written conversational trail of students' progress in thinking and researcher reaction to it throughout the course. While students were encouraged to write about any experience or reflection, there were specific questions, topics, or issues identified for journaling each week. These questions were based on a combination of the goals of the week's activity and the nature of the discussion during the class period. The journaling questions posed for each of the four weeks STF was assigned were as follows:

STF week 1:
1) Watch and analyze Vickie Bill on STF. Based on what you see, what are three things you believe contribute to good mathematics teaching?
2) Evaluate STF — what do you think is helpful? Any complaints?

STF week 2:
1) Last week you wrote about three things you believe contribute to good mathematics teaching. Since then you have watched David Birchfield on STF. As a result of that additional experience, what would you like to add to or change in your previous journal entry? Explain why.
2) Discuss and comment on the questioning strategies used by Vickie Bill and David Birchfield. Explain why you think their strategies are effective or ineffective.
3) Identify the two aspects of STF as a technology that have been most useful to you. Explain. Identify the two aspects that have been most confusing or frustrating. Explain. Overall, how useful has STF been in helping you develop notions of good mathematics teaching (on a scale of 1 = not at all helpful to 10=extremely helpful)? Explain.

STF week 3: What are your questions, concerns, and insecurities about your field experience. How do you plan on approaching these concerns? Use STF to explore and comment on these issues.

STF week 4:	1)	Discuss the group lesson planning experience on Sept 26. Was it helpful? Could it be improved?
	2)	Discuss your field experience and any issues that it is raising for you.
End of course		Students were asked to reflect on their STF experience at the the end of the course in a journal assignment and in the course evaluation.

The journal entries for the entire semester were analyzed for the eight case study students in the class (see "Subjects") using the Constant Comparison Method outlined by Glasser and Strauss (1975). The entries were divided into idea units, defined as a focused comment about some event or experience. The first and third authors worked on successive samples of journals until they established 80% agreement on the division into idea units and they could apply those divisions to another sample with similar agreement. Then the third author divided the remainder of the journals into idea units.

The idea units were sorted by each of the researchers into categories of ideas that seemed to go together. The categories were then named. Several iterations of this process led to a matrix of categories into which comments about experiences were placed. Idea units were categorized on two dimensions: the experience that was being reacted to; and the type of comment about that experience. The experiences being reacted to are the primary instructional components of the course plus prior experience as learners and teachers: STF, the field experience, their teaching experience, the interview assignment, activities in the Math Methods class, other ECGP classes, and experiences outside of the University program.

The comments on each of those experiences were first sorted into two categories: comments that discussed what was learned from the experience; and comments on the design and effectiveness of the experience as part of the course, e.g., how the use of STF could be made a more effective part of the course. This classification scheme is represented in the table below (see Table 1). Some comments were also cross-categorized in terms of how the experience helped them develop new insights on: teaching practices; learning and schooling; specific teaching strategies (e.g., the strategy for questioning); guiding their personal development as a teacher; their current teaching style/beliefs; and mathematics as a discipline.

Table 1

Data Categorization Scheme

	Comentary on/ Learned From	Evaluation of
STF		
Field Experience		
Teaching (including video of them teaching)		
Interviewing children (including video on interviewing skills)		
Instructor's Activities		
Other EGCP Classes		
Non-University Experience		

Once the categorization scheme was in place, the first and third author independently categorized a random selection of 13% of the comments to establish reliability. This process yielded 80% agreement. Considering the substantial number of categories and the placement of comments into multiple categories, we believe 80% agreement is more than acceptable. This complete analysis is supporting a larger research effort. For purposes of the research reported here, our focus is on the nature of the comments about STF.

Teaching videos and reflections on teaching. During the last two weeks of class, volunteer students (twelve in all, including seven of the eight case study students) brought in one of their own videotaped lessons and reflected on their own teaching with the third author. Students were told to be prepared to show and critique examples of questioning, problem solving, and group work. These discussions/interviews were audio taped, transcribed, and unitized in the same manner as the journal comments.

Teacher Reflections Towards the end of the semester, the third author interviewed the instructor (first author) about her expectations of the system, the use of STF in her class, the resulting impact of its use during the semester, and ways in which its use could be modified for future classes. The interview was audiotaped and transcribed.

Results and Discussion

The use of STF

Twenty-nine sessions on the STF system were recorded with an average overall length of 58.37 min. per session. Students used the system outside of the normal class time more often than they used it during class: 13 in class sessions vs. 16 out of class sessions. Generally all four members of the team participated in the sessions. However, the sessions outside of the classroom did vary in group size with at least one of the sessions involving one student working with STF on her own.

All twenty-nine sessions occurred during the four weeks that STF was an assignment in the course. Although the students used STF outside of classtime and were enthusiastic in their assessment of it, they did not use STF from weeks six to thirteen as an explicit tool for preparing the lessons they taught in the school or for reflecting on their teaching afterwards. Most students felt there was only so much they could learn from the two teachers in STF and indicated in their journals that they wished they had more STF teachers to view. Their choice not to return to STF after the first month most likely represents this saturation.

Table 2 summarizes the mean amount of time spent on each of the components of STF and the proportion of the total time that it represented. We were surprised to find that the students distributed their time rather evenly over the three primary information resources: the video (26%), the commentary on the video (21%), and the database of information on the teaching strategies (26%) represented in STF. The use of these three components represented 70% of the time spent on STF.

Table 2
Distribution of time spent on the components of STF

	Activity						
	view video	listen to perspectives	use database	view elaboration	listen to orientation	use notes	Totals
Mean Time	15.35	12.37	15.00	1.80	1.19	4.10	49.81
Proportion of Total Time	26.3%	21.2%	25.7%	3.1%	2.0%	7.0%	85.3%

There were some differences between the STF sessions that occurred during the regular class schedule (classtime STF) and those sessions initiated by the students outside of the scheduled class time (after-class STF). The after-class STF sessions on average were shorter in duration (53.3 and 67.2 minutes respectively). In the classtime STF sessions, the focus tended to be on viewing and discussing the videos, with this activity consuming 47.7% of the session as compared to only 12% of the after-class sessions). In contrast, the after-class sessions tended to focus on the use of the information base with 36.2% of the session spent in the database as compared to 10.4% of classtime sessions. For both classtime and after-class sessions the students spent about a fifth of the session (22.4% and 20.3% respectively) listening to and discussing the expect perspectives with a mean of 5.5 and 6.2 perspectives respectively listened to during a session.

There had been some concern that students would simply view the videos and not engage in any analysis beyond that generated from their observations. Therefore, we were pleased to see that all threo of the primary STF information resources — videos, perspectives, and the database -were used about evenly. While the assignment required the students to analyze the videos, that analysis did not specifically require viewing anything beyond the videos themselves. Hence, the extensive use of the database and perspective resources does suggest that the students found this supportive information useful in their analyses.

The Ease of Use

The use of STF was not without technical problems. However, most of the problems occurred with just one of the four stations. There were persistent problems with this station in accessing the audio and, on occasions, it was difficult to start the program. The cause of the problems was never identified. These problems led Gary, one of the students, to say, "Has a day yet gone by when all four STF set-ups were all working properly without any problems? . . . If so, how many days in a row?" The only other equipment difficulties occurred when cables connecting various pieces of the STF system were switched by people using the computers for non-STF work, including connecting the computer to the LAN (which slowed down the responsiveness of the computer), disconnecting the CD-ROM player, and disconnecting the videodisk player. The students generally had to seek help to reconnect the equipment.

While the instructor had initial concerns regarding the ease of use of the system, looking back she stated, "My worry about the students being able to handle the technology probably was unfounded . . . I think some of [the problems] — and it's not the system at all — [were] simply our own physical environment." The instructor did express some concern about using the system without the technical support she received during this project. She doesn't feel confident that she could troubleshoot minor hardware problems that might arise.

STF, itself, was easy for the students to operate. Even novice computer users felt that they adapted to the system quickly. After the first week Matt stated, "I have enjoyed using the STF throughout the past week. Knowing so little about cutting edge computer technology, it was a pleasant surprise to be working with something that is so logical and user friendly." Students had few complaints about the STF interface and few suggestions for improvements. Tina commented that she disliked having to turn the videodisk over as often as she did, and Matt found that the screen saver on his workstation was distracting. Additionally, Pete commented that he wished he had the opportunity to see the entire lesson without a break (the videodisk stops at natural pauses in the classroom, thereby breaking the lesson into many 1-5 minute segments as opposed to one long 40 minute video).

The usefulness of STF

In this section, we report the students' and instructor's sense of the usefulness of STF as a tool for learning. Their comments fell into two broad categories. First, there were comments on the particular components or features of STF. Second, there were comments on the placement and role of STF in the curriculum — its perceived usefulness where it was placed and its relation to other components of the curriculum.

Value of specific STF features. In the initial design of STF, there was some discussion of the value of placing the teaching video on videodisk. We wondered if students could be equally well served by a lower-tech version of the system consisting of videotapes and hard copy printouts of the commentary. How important are the interactive elements of the Hypercard/laserdisk system? The Cognition and Technology Group (1992) has argued for the value of laser disk for rapid access in reviewing and discussing the videos, and our students seem to agree. Starting with the fourth week of the course, we made available videotape copies of the classrooms along with hardcopy transcripts of the comments. However, the tapes and hardcopy were not used, even while the students were still making extensive use of the computer based system. Indeed, Pete indicated that he liked the control provided by the videodisk player, stating, "I like being able to replay what they did and hearing several different explanations for why they do certain things. It really gives us a chance to get to the nuts and bolts of teaching. It is one thing for someone, to tell us how to do it. It is something else to see someone doing it in a real world setting."

Pete also noted the value of the perspectives on the teaching that were provided: "I like having the comments of the teacher and expert commentary right there with the video. I get to hear their comments while what happened is fresh in my mind. I can play the video back immediately if I don't know what the comments are about." Other students echoed similar sentiments, saying,

> It is also beneficial to hear what teachers have to say about their own classroom practices. It's nice to know firsthand what seems to work and what doesn't. The comments the teachers make can really help a prospective teacher shape their own beliefs about what may or may not work in the classroom. (Donna)
> The feature I liked the most were the on-line comments, assessments, and critiques of the teacher. They are essential in giving a context to what is being viewed, and they really helped me to focus on why this teacher was better than most and the things that she did that were most (or least) effective. (Sam)

There were a large number of comments from the students praising STF for teaching them by example (and letting *them* decide what to make of the examples), rather than by telling them what good teaching should be. In effect,

they told us that they recognized STF as the constructivist environment that it was designed to be and appreciated the fact that the STF experience aligned well with the philosophy of the rest of their teacher education program. Laura put it this way,

> We are learning in our classes to provide students with as many experiences as we can to help them develop strategies that are best for them. STF provides us with those same opportunities. We are exposed to many different teaching methods. By having these different experiences to learn from, I am better equipped to find what method is better for me.

Tina explained the same thing somewhat differently,

> I like the fact that taken together the system not only presents a variety of places, but an assortment of teaching styles and several commentaries on the advantages and disadvantages of each one. This helps you understand that good teaching is often a matter of opinion and you need to figure out what works for you. And it helps you do that.

In a later journal entry, Tina elaborated on her earlier comments about the importance of having a variety of exemplars:

> STF is helping me because it provides a means of comparison that I might not have had otherwise. I knew when I first saw Vickie's class that I did not like it. I did not know why. It was just instinct. It just did not work. But after watching David Birchfield I could see why I disapproved. It is like you do not really know what "hot" is unless you have experienced cold also. STF provides both and thus provides me with a means of seeing more clearly what I like and do not like and why.

Matt claimed that the natural anxiety experienced by all preservice teachers had been alleviated somewhat because he had seen multiple exemplars of good teaching.

> Using STF has given me another frame of reference to draw from while in the classroom; because of that, the level of anxiety that I am now experiencing is only a fraction of what it might have been, had I not experienced various strategies and styles via STF.

In a later journal entry, he claimed that STF had also helped him with self criticism.

> Being able to watch a larger variety of teachers has also helped me in the critique of my own ability. For instance, by watching a variety of teachers, I have found that I have a broader range of comparison, both for my own teaching and in evaluating their teaching.

However, most of the students agreed that the availability of more exemplars would improve the STF system considerably. As Tina put it,

> STF is really good resource, but without more teachers and lessons on it, it exhausts its possibilities after a while. It is such a good idea that I hope that the creators will add a lot more examples to it soon.

The instructor also indicated that the use of more exemplars over a wider variety of grade levels would be beneficial to students. With more exemplars, she could have students look at how teachers handle different mathematical concepts such as fractions, shapes, etc.. With only three lessons on the system, the opportunity to use it to support teaching of specific concepts is extremely limited.

STF as a curriculum component. One of our main concerns in this project was to learn how STF could best be used in a preservice teacher education course. In this study, STF was used as a "substitute" for field work at the beginning of the semester. It was seen as a way for students to "visit" models of teachers incorporating the NCTM Standards prior to being immersed in the field experience. One set of curriculum issues centered upon the placement of STF in the curriculum. Here, responses were generally positive — we seemed to have gotten it mostly right. The

second set of comments, discussed STF relative to other components of the course. Here there was strong sentiment that STF is no substitute for actual classroom experience. The students' and instructor's commentary related to these issues follows.

The use of STF at the beginning of the course, prior to the students' placement in schools, was pointed out by several students as being a very appropriate use of the system. As Donna stated,

> I'm glad we were able to view Vickie and David before we began our field experiences because I think they gave us a framework of reference, or ideas, to work from. While we must each adapt our own teaching style, it helps to have ideas that "work" from practicing professionals.

Other students also recognized that the early introduction to Vickie and David helped to establish their early views about teaching. Sam commented that "Vickie and David helped me form my own early view about what teachers do, and what they should do. I'd never seen or experienced someone teaching like either one of them, but in retrospect, I really wish I'd had."

The instructor felt that the students "got off the mark a lot faster than the class I taught before" in regards to their understanding and reflections on mathematics teaching and teaching in general. She stated, "With doing workshops with them with hands-on materials and so on, so that by the end of two weeks, they already have a totally different picture of what math teaching is all about . . . and having used STF . . . they have that different picture." Despite this, she would like to utilize STF throughout the semester. Ideally, she would like to "be able to have it right in the classroom, so that on any day that we had our methods class, we could say, 'Let's break up right now and spend 15 minutes . . . .'"

While most students appreciated the use of STF, almost all believed that hands-on time in the classroom was even more valuable to them. Some students indicated in very strong terms that any time out of the classroom was wasted time:

> Now that I think about all the time we spent using it, we could have spent 4 more afternoons in the classroom — that would have been 12 more hours of practical classroom experience. . . . I did observe teaching and learning through STF, but I wasn't there. I couldn't walk around. I couldn't really see what all of the students were doing and I couldn't ask questions of the teacher or students. If I had a question other than the programmed responses that were provided, I was out of luck.

Gary echoed similar sentiments:

> Anything that kept us out of our classroom was less valuable than the classroom experience would have been and therefore, a sacrifice. I did enjoy watching the two STF videos, but would rather have done that in one afternoon instead of three.

Jennifer made a similar comment about the number of examples that students were able to analyze via STF vs. classroom observation during the same time frame: "Instead of watching those two [Vickie and David] teach the same lesson four weeks in a row, I would much rather have watched my teacher teach four different lessons." However, she goes on to say, "This is not to say, however, that I did not get any ideas from STF as to what I would like and would not like to do in my class — I did."

Other students recognized that while nothing replaced actually being in the classroom, STF did provide a useful substitute. As one student stated, "I truly believe that I need to be in the classroom to achieve full understanding of what is and is not effective; but this [STF] is a great substitute."

Gary had very strong sentiments about the expenditure of resources and funds used to create system of this type. He commented, "to me, STF is just another impediment to having a fifteen-to-one student-teacher ratio." He later expanded on this thought by stating:

> It's not that I dislike the lessons that I got from the STF, they were certainly useful. I just can't help thinking about all of the resources that were tied up delivering those two lessons. I don't think it's worthwhile. If I ask myself: "how much better of a teacher will I be for having been exposed to STF?," in all honesty, I have to answer: "not that much."

BEST COPY AVAILABLE

Use of STF was only one part of an entire course designed to get students to think about and practice teaching in the style of the NCTM Standards. This integration and focus of all aspects of the course to a common goal makes the contribution of individual components difficult, if not impossible to determine. Two of the eight case study students recognized and commented on this facet as well. Laura discussed how various components of the course opened up her mind to new ideas, stating "from my readings, . . . viewing the STF videos and in-class videos, and interviews, I am beginning to give kids credit and keep myself open because I think they will surprise me and exceed my expectations." Reflecting back on the course at the end of the semester, Matt commented on the integration of STF with the other aspects of the course in being fundamental in his growth:

> No individual experience in the math methods course would have been complete without the other sections to compliment it, and in that sense it seems to me that all sections of the course meshed together well and developed into a final product that was very conducive to understanding of mathematics in the elementary classroom.

How STF impacted understanding.

STF teachers as mental models. One of the primary goals of the course instructor was to provide exemplars of teaching math that the students could "see" since the cooperating teachers they were placed with may or may not be teaching in the spirit of the NCTM Standards. She felt that students would be able to "get a chance to do more than just see the classroom, but that they could sort of get inside the teacher's head, or get inside some other people's heads about what's going on." Student comments and observation of students in the field indicate that the teachers in the STF videos did serve as mental models of good teaching for the preservice teachers at the same time as they helped them develop their personal philosophies of teaching. As Sam explained,

> I can easily say that my exposure to David helped me to lay the foundation of my educational philosophy. He gave me a valuable reference point and standard to aspire to . . . . It really helped me throughout the semester to have David in the back of my mind as a baseline.

A comment in Matt's journal reiterates Sam's point: "I used the STF system as a frame of reference for each of my field experiences in one way or another throughout the entire semester."

In addition to keeping exemplars of good teaching in the backs of their minds, many of the students actually modeled at least some of the lessons they taught in their field experience classrooms after lessons they had viewed on the STF videos. For example, Sam used numerous features of David Birchfield's first grade measurement lesson in designing his own first grade lesson on place value. Some students even consciously imitated the STF teachers. As Matt admitted, "I guess we can't get much closer to modeling my teaching behavior about the STF than this, because I basically stole David Birchfield's activity. . . . I basically tried to be David Birchfield in this lesson." It turned out that Matt found using David as a mental model both helpful and distracting, as comments from his self-critique interview indicate. Matt opened the discussion of his teaching video with the following self-analysis,

> I think I was able to be relaxed somewhat in front of the class as a whole in this video, but when I was working with the students one-on-one, I was too concerned about moving around the room and trying to be like the model STF teacher.

Though Matt's use of STF as a model was purposeful, other students claimed that their use of STF models was not entirely a conscious decision. For example, Tina wrote in a journal entry that she was surprised how much STF images affected her teaching:

> I was very critical of Vickie at the beginning of the semester. But only a few weeks later I gave several lessons that were very much like hers and I returned to her in my mind as a consultant on how to improve.

Later, in the interview during which she analyzed her own teaching video, Tina elaborated on this comment.

> [At first] I hated Vickie Bill. I just hated it. I hated it, hated it, hated it — the whole approach. . . . I still have a few mixed feelings about her teaching, but the thing that's funny about it is that I feel like, in a lot of ways, my teaching has turned out a lot like hers. . . . As I look back, I'm seeing more and more the merit of her approach.

Tina was not the only student whose standards changed during the course of the semester. For example, Pete originally thought that David Birchfield was too stern with his students. After several weeks of field experience, Pete changed his mind. "When I look back at my observations of David Birchfield I think I was way too severe. . . . . I find myself being just as stern as he was in the video." Matt originally thought the self-critiques provided by STF teachers were too analytic. In time, he came to value the attention to detail that these critiques provided.

> Early on in the semester, . . . it seemed to me that they [STF model teachers] were too critical of their own teaching style and reading too much into their own actions. My opinion now contrasts sharply . . . It seems to me that attention to detail is a key factor in understanding the effectiveness of one's own teaching skills/weaknesses.

After teaching in his field experience classroom for weeks and after viewing himself on videotape Sam really appreciated the exemplary teaching modeled by the STF teachers. As he explained,

> I found [STF and self-videotaping] really, really useful. . . . They [STF teachers] make it look so damned easy . . . then when I saw my videotape and compared it, it was just like, "my god!" There was such a big gulf there. . . . That was really helpful. I really liked being able to compare [my] video . . . and the other ones.

Donna summed up the students' general reactions to the availability, through STF, not only of models of good teaching, but also of models of self critique:

> I would say it [STF] is most useful as an instructional tool, because it allows you to see other teachers "perform" in the classroom. It is very helpful to see, and hear, how teachers develop their lessons and also hear their comments on classroom management, how the lessons are progressing, etc.

The instructor recalled a specific instance where David Birchfield served as a mental model during a classroom discussion, "When we dealt with the session on counting and pre-number ideas, then I know that I referred to the things that they had seen in David's class . . . [STF] was so useful, because we had at that point a common reference of good teaching."

Specifics learned from STF. The STF system was not only effective in providing students with overall models of good teaching, but also in providing examples of a variety of specific strategies and techniques. For example, most of the students had very little experience with small group work in school, but they were anxious to try it in their teaching. They appreciated what they could learn about this new pedagogical technique from STF. As Matt commented,

> [From STF] I was able to learn specific group-related activities that I was able to apply to math activities for my second grade class. . . . I [also] drew the idea of assigning different roles to specific group members from the Dwight Cooley video on STF.

The students also mentioned how much they learned about effective questioning techniques by watching the STF videos and listening to the related perspectives. Sam put it this way,

> I really like the way that David Birchfield, when he's moving from group to group, his skill at questioning them is a lot better than mine. . . . I was walking around and kind of doing the same trick that I learned from him, which was keeping one eye open on everyone else and watching what specific ids are doing. . . . I really identify with the kinds of things I learned about from David Birchfield. He makes that kind of think look easy, . . . and it's not.

Laura appreciated the many management and organizational tips she gleaned from STF. She wrote, "After watching David Birchfield, I feel even more strongly about organization. . . . He had certain practices to identify

transitions, like a song or the turning off of the light." Matt noted that he really had never given much thought to classroom management before observing hearing the STF teachers explain the management techniques they were using:

> I feel that one of the reasons I was able just to manage the students somewhat effectively in this lesson, is because of watching the STF video system and just getting a better understanding of how teachers can move around a classroom. . . . I was never really aware that I could actually have a strategy of moving around the classroom before watching STF.

He also noted that observing via STF had prepared him for most purposeful and effective observing in his field experience classroom:

> Vickie Bill was more influential in terms of learning effective management techniques through questioning, planning, and leadership. After watching Vickie, I was able to notice that my cooperating teacher had a similar situation of effective management established in her classroom. I was able to use my cooperating teacher's management system early in the semester, having been primed for such a thing by watching the STF.

Stimulating thinking about teaching. Watching STF not only gave the preservice teachers specific strategies to use in teaching, but also raised a variety of issues that they debated in class and wrote about in their journals. For example, many were anxious to know how Vickie Bill had set up her classroom at the outset of the school year. They admired the classroom's organization and the students' clear understanding of rules and expectations (as seen in the video clips of Vickie's teaching), but they wondered how that atmosphere had been established. As Sam put it,

> The most intriguing comment I heard on the disc is the one where she [Vickie] states that the first 5 days are used to set up her system and class the way she needs to. I want to know exactly what she tells those kids and what they do the first five days in greater detail. I'm sure there is lots of valuable info there.

Some of the students had just as many questions for David as for Vickie. The students seemed to think of Vickie and David as experienced colleagues and wished they were available for personal consultation or friendly teacher-lounge conversation. Writing in his journal, Matt expresses their sentiments well: "I would like to ask David a few questions. I have created a list that I would like to talk to him about, and will continue to add to it for the rest of the semester."

The students mentioned numerous ideas obtained from STF that they wanted to debate or to learn more about. For example, they were generally attracted to the notion of creating their own mathematics curriculum (rather than relying on a textbook), but concerned about how a teacher can actually manage to do this in practice (and whether they, as novices, could pull it off). In one of the STF perspectives, Vickie Bill explains that she uses student logbooks as a record of the ever evolving curriculum in her classroom. Gary commented in his journal,

> I love [Vickie Bill's] idea of using logbooks for texts. I hope after I've had a few years of experience under my belt, I'll have enough confidence and ambition to abandon the textbook and custom design my math lessons, or at least many of them. This way they could be tailored to the specific needs and abilities of the class.

Laura expressed similar sentiments:

> Another problem posed by STF is whether or not to even use a textbook like Vickie did not. It seemed to really work for her and her students, but I know at this time I am not even close to being able to work without a text.

Laura also noted, with a bit of surprise, that not all of her classmates reacted with the same enthusiasm to Vickie as a model. Laura appreciated a class exercise where students were required to justify their opinions about the effectiveness of the STF teachers by pointing to specific incidents in the videos.

I thought Vickie Bill was more effective and that would be self evident to everyone. But this was far from true. There are those who found David's use of creativity better than what they perceived as Vickie's overly organized and hard to follow lesson. By making them and me give specific examples, hopefully we are better able to see how or why the other can think the way he does.

Summary and Discussion

Our focus in this study was to document how the Strategic Teaching Framework (STF) could be used in a teacher education course to provide models of teaching-in-action about which prospective teachers could reflect and debate. Our goal was to facilitate the development of teachers comfortable with teaching according to the recommendations of the NCTM Standards and thoughtful about their development as flexible practitioners. Our setting for the study was the field experience component of a masters certification program for prospective elementary teachers. Our data documented how the students used the technology, as well how they planned and taught lessons to actual classes of students and how they reflected on teaching and learning issues in class discussions and in their individual journals. We were not surprised to observe that, as novice teachers, the PSTs were not able to teach lessons that came up to the standards they had learned about. Therefore, documenting the PSTs' growth in reflective understanding across their analyses of these very different types of teaching episodes was of particular interest.

We are still interested in exploring further how STF could best be utilized in this course. Its use at the beginning of the course allowed the students to have a "virtual" field experience. Many students commented on its importance in providing an early model for them to draw upon. However, other students felt that the time spent on STF (four hours a week/three weeks in row) was too much. We wonder if STF would be better utilized if it were interspersed throughout the entire class as opposed to loaded at the front end.

One of the students (Laura) devoted much of her journal to discussion of age appropriateness. In particular, she wondered if the differences she saw between David and Vickie's teaching strategies and styles were due to the differences in the ages of their students. Other PSTs also mentioned that they wish they had a specific exemplar of the grade level they were working with. We are curious as to the importance of specific grade-level exemplars. How close to the students' actual situation do video models need to be? What aspects of teaching transfer across grade-levels and which are better served by specific age (or for that matter, content) exemplars?

In any case, from the way in which STF was incorporated in this class we learned the following. PSTs were avid users of the STF system, prolific and thoughtful writers of journal entries, and eager participants in discussions about what they gained from use of STF. In a number of cases, the lessons that they taught in the schools were explicitly modeled on lessons viewed in STF—and in their self-critiques of these lessons the PSTs provided rationale for their choice of lesson and reflected thoughtfully on how and why they had adapted these models. Our PSTs reported (and evidenced) important changes over the course of the semester in their views of mathematics and of what constitutes effective teaching. The teachers in the STF system proved to be important models for the PSTs, while the commentary provided within the system provided a springboard for student reflection and discussion both in their journals and in the class. An important side benefit STF provided was its use as a common image and reference point for the students. Throughout the semester, students were able to refer to specific instances in the videodisks or comments made in the commentaries and generate discussion with everyone else in the class since everyone understood the reference.

To be effective, teacher education programs and classes should model what they teach. We feel that integration of STF into this field experience provides students with important models outside of the teachers on the videos. First, it models an appropriate use of technology that allows students an experience they could not have had otherwise. The technology in this instance extends their boundaries of observation and experience far beyond the traditional field experience, allowing them to see and communicate (via the perspectives) with expert teachers. If teacher education classes do not model appropriate uses of technology, then we cannot expect new teachers to develop an understanding of technology's potential, for both good and bad,in their teaching. Additionally, the constructivist framework underlying the design of the software is consistent with the philosophy and goals of the Standards. This provides another important, if subtle, model for the students. As they work, grow, and construct their own ideas about teaching, STF provides a learning environment which exemplifies the goals of the Standards. Learning in this environment can help the students understand the meaning of "constructing knowledge" and help them to be better able to create similar experiences for their students. While we recognize that it may be impossible to isolate the influence of STF from other influences on our PSTs (methods instruction, class discussion, school observations, etc.), we feel confident, nevertheless, that use of STF contributed significantly to the M501 field experience.

BEST COPY AVAILABLE

References

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

Burns, M. (1993). Assessment in Mathematics. [Video and Discussion Guide]. New York: Cuisenaire .

Case, R. & Bereiter, C. (1984). From behaviorism to cognitive development. Instructional Science, 13(2), 141-58.

Cobb, P. & Steffe, L. P. (1983) The constructivist researcher as teacher and model builder. Journal for Research in Mathematics Education 14,(2) 83-94.

The Cognition and Technology Group. (1992). Technology and the design of generative learning environments. In T. M. Duffy & D. H. Jonassen (Eds.), Constructivism and the technology of instruction: a conversation (pp. 6-89). Hillsdale, NJ: Erlbaum.

Davis, R. B. (1984). Learning mathematics: The cognitive science approach to mathematics education. Norwood, NJ: Ablex.

Duffy, T. M. (in press) Strategic Teaching Framework: An instructional model for a constructivist learning environment. In C.Dills and A. Romiszowski (Ed) Instructional Development State of the Art, Volume 3: Paradigms. Englewood NJ: Educational Technology Press.

Duffy, T. M.., Jones, B. F., & Knuth, R. (1993). Strategic teaching frameworks: A hypermedia system to support strategic classroom change. Unpublished manuscript, Bloomington, IN: Indiana University.

Fishman, B. & Duffy, T. M. (1992). Classroom restructuring: What do teachers really need? Educational Technology Research and Development, 40(3), 95-111.

Glasser, B. & Stauss, A. (1975). The discover of gournded theory: Strategies for qualitative research. Chicago, IL: Aldine.

Hiebert, J. (Ed.). (1986). Conceptual and procedural knowledge: The case of mathematics. Hillsdale, NJ: Erlbaum.

Karlsen, J. I. (1991). Reaction research as method. In W.F. Whyte (Ed), Participatory action research (143-158). Newbury Park, CA: Sage.

Kloosterman, Peter, & Stage, F. K. (1992, March). Measuring beliefs about mathematical problem solving. School Science and Mathematics, 92(3), 109-115.

Lambdin, D. V. (1993). Monitoring moves and roles in cooperative mathematical problem solving. Focus: On Learning Problems in Mathematics, 15(2-3), 48-64.

Lambdin Kroll, Diana, & Miller, T. (1993). Insights from research on mathematical problem solving in the middle grades. In D. T. Owens (Ed.), Research ideas for the classroom: Middle grades mathematics (pp. 58-77). New York: Macmillan.

Lampert, M. (1985). How do teachers manage to teach? Harvard Educational Review, 55(2), 178-94.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. American Educational Research Journal, 27(1), 29-63.

National Council of Teachers of Mathematics. (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: NCTM.

National Council of Teachers of Mathematics. (1991). Professional teaching standards for school mathematics. Reston, VA: NCTM.

Schon, D. (1988). Educating the reflective practitioner. San Francisco: Jossey-Bass.

Schoenfeld, A. (Ed.) (1987). Cognitive science and mathematics education. Hillsdale, NJ: Erlbaum.

Stoiber, K. C. (1992) The effect of technical and reflective preservice instruction on pedagogical reasoning and problem solving. Journal of Teacher Education, 42(2), 131-139.

Tobin, K. (1989). Teachers as researchers: Expanding the knowledge base of teaching and learning. In M. L. Matyas, K. Tobin & B. Fraser (Eds.), Looking into windows: Qualitative research in science education (pp. 1-7). Washington, D. C.: American Association for the Advancement of Science.

Zollman, A., & Mason, E. (1992). The *Standards* beliefs instrucment (SBI): Teachers' beliefs about the NCTM *Standards*. School Science and Mathematics, 92(7), 359-364.

17